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INGREDIENT HANDLING BY FEED MANUFACTURERS

Capital and Labor Requirements

MARKETING RESEARCH REPORT NO. 727
UNITED STATES DEPARTMENT OF AGRICULTURE • ECONOMIC RESEARCH SERVICE

PREFACE

This is the fourth in a group of studies conducted by the U.S. Department of Agriculture on different phases of feed manufacturing. Earlier studies were reported in "Labor and Capital for Pelleting Formula Feeds," Marketing Research Report No. 463, "Labor and Capital for Mixing Formula Feeds." Marketing Research Report No. 564, and "Operating Costs in Packing Mixed Feeds," Marketing Research Report No. 658.

Work of this type is part of the Department's broad program of research to expand market outlets and increase efficiency in marketing farm products. The farmer has double interest in this industry's efficiency since he produces the feed ingredients and also purchases the finished product.

CONTENTS

July 1965

SUMMARY

Feed manufacturers are confronted with many problems, one of which is the need to renovate the receiving center for a more efficient operation. Receiving is a major area for change since bulk handling has moved rapidly into the feed manufacturing operation.

Mill management has attempted to convert the receiving center to bulk handling since there are definite savings through bulk ingredient purchasing as well as increased labor efficiency. Two basic model receiving centers which receive 80 and 200 tons a day are used to show labor standards and efficiencies obtainable in feed mills. Approximately 80 percent of the material received in these models is in bulk form.

The smaller model, receiving an average of 64 tons of bulk ingredients per 8-hour day, requires equipment costing about $64,280. This model requires about 7 production man-hours per day plus 1.5 man-hours of supervision. Total labor used by the model is .11 man-hours per ton. Labor cost accounts for more than one-third the total cost. Total annual operating cost is $13,241 or about 64 cents per ton.

In the larger model, 160 tons of bulk materials are received in the average 8-hour day. Cost of equipment and installation for this size of operation is about $101,110. Production labor necessary to unload this quantity in 8 hours is 14.11 man-hours. About 3 man-hours per day are required for supervision. Total labor used by the model is .09 man-hours per ton. Annual operating cost is $25,362, or 50 cents per ton.

In comparison of operating costs, the larger model's cost per ton is about 78 percent of that for the smaller model when both are operating a single shift. When the 80-ton model operates 2 8-hour shifts, its cost is equal to the 200-ton model's 1-shift cost. The larger model's cost increases to about 82 percent of the smaller model's cost when both are operating 2 shifts.

The number of feed-manufacturing facilities using pneumatic conveying has increased with the increasing percentage of bulk handled in recent years. Alternative systems using pneumatic equipment suitable for the models have been set up for a comparison of costs. The alternative pneumatic system for the smaller model costs about $54,780, or 85 percent of the mechanical equipment cost. However, higher depreciation, labor, and electricity makes the annual operating cost per ton for the pneumatic system about 16 percent higher than for the mechanical system.

The same relationship is found to exist in a comparison made with the larger model. The alternative pneumatic system of the proper capacity is less expensive than the mechanical system in the model. It would cost approximately $96,130, or 95 percent, of the mechanical system's cost. Annual operating cost per ton for the pneumatic system would be about 8 percent more than for the mechanical system.

Many feed manufacturers in the industry are concerned with higher cost of handling bagged materials. This cost is higher than bulk handling but it can be reduced by a number of techniques. Several special attachments have been placed on the market which would reduce both labor and pallet cost.

One such innovation is the bag-handling clamp for forklift truck which eliminates some of the labor required in handling and palletizing bagged material. By using this, it is estimated that a mill could save $450 initially in storing an average of 400 tons of material on pallets. Greater savings would be realized annually through the elimination of maintenance expense for wooden pallets, plus labor cost.

Management's solution to most problems of materials handling usually involves a compromise of several possibilities. In selecting a system for a new mill or in renovating an older mill, management attempts to select the most practical one. The selection may be a combination of 2 systems. The decision usually involves a detailed study of cost analysis and cost comparison.

INGREDIENT HANDLING BY FEED MANUFACTURERS CAPITAL AND LABOR REQUIREMENTS

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INTRODUCTION

The mixed feeds industry of today is very different from the diversified group that manufactured formula feeds prior to World War II. During the early 20th century, feed was marketed through local elevators owned and operated for the most part by the flour millers. Grains and grain byproducts were blended to meet a few basic requirements that most manufacturers believed sufficient for livestock production. However, in a relatively short time the feed manufacturer has become a specialist, producing a feed designed to do a specific job at a certain time in the feeding program of a particular class of livestock. From a few basic formulas containing maybe 10 ingredients, the average manufacturer has now progressed to many formulas containing 20 or more ingredients producing a nutritionally balanced diet.

The industry growth is largely a result of applied research. Research has proved how production of poultry and livestock (and their products) can be increased by certain feed additives such as vitamins, antibiotics, drugs, and hormones. These can be blended with the basic ingredients in a formula for more efficient feed conversion.

Feed manufacturers striving to obtain or retain a share of the rapidly expanding market continue to make changes in their organizational structure. Many plants have remained at terminal grain and ingredient market locations, while others have decentralized. Regardless of location, each operation seeks more efficient ways of manufacturing and distributing mixed feeds. Outstanding gains have been made in materials handling; bulk handling and automation have enabled the industry to increase efficiency and reduce costs.

The receiving center of feed manufacturing plants is a good illustration of this trend. Today, many plants receive more than 90 percent of the materials used in manufacturing feeds in bulk, whereas a short time ago only grains were received in bulk. This practice requires less labor and is usually confined to the less expensive ingredients. Usually, prices for bulk ingredients are $5 a ton under those for bagged ingredients. Thus, savings are twofold for the manufacturer.

The purpose of this study is to provide information which will enable management to make knowledgeable decisions concerning the operating efficiency of their receiving centers. In developing guidelines for planning new or remodeling existing feed mills with automated methods, the primary objectives are: (1) to reduce labor per ton for receiving materials while maintaining their quality, and (2) to improve the overall efficiency of the mills.

METHODOLOGY

Two model receiving centers are used in this report to provide standards to be used in analyzing this segment of the feed plant operations. The basic data used for these models were obtained from a mail survey of 225 selected feed manufacturers in

34 States. Personal interviews were obtained in a sample of the participating firms. Other pertinent information on equipment costs, electricity rates, and wage rates needed to complete the analysis was obtained from industry and Government sources.

Model plants of 2 volume sizes, 80 tons and 200 tons per 8-hour shift, are used since these best represent the survey plants. Typical operations for each model have been modified with the assistance of equipment-manufacture engineers. Labor standards used in the models have been similarly obtained.

Other cost items considered in the models were estimated with the assistance of industry and Government personnel. Several of these represent average costs for the United States and are not intended to be the rates for any particular locality.

RECEIVING CENTER OF TYPICAL FEED MILL

The receiving center is 1 of 6 major operations of the feed-manufacturing process. They are: receiving, processing, mixing, pelleting, packing, and warehousing. These centers are so defined that it is possible to analyze each one separately.

Functions of the receiving center begin when the materials arrive by railroad car or truck at the unloading point and end when the materials are in holding bins or in the receiving warehouse. In this center are included receiving, storing, and handling of all incoming raw materials such as empty bags, tags, strings, and other supplies. Another responsibility of this center is to maintain the quality and condition of all ingredients received by the mill.

Capital investment for receiving facilities (equipment, storage bins, etc.) is high in relation to other centers in the mill. However, the manpower required is relatively small. Generally, newer plants have more automation, which tends to reduce man-hours per ton of incoming material but requires more skilled labor.

The receiving equipment and building space allotted to the storage of materials depend largely on the volume and variety of feeds manufactured. For example, a plant manufacturing only broiler feeds and using a prepared concentrate would need only a fraction of the equipment and storage space required in a full-line feed mill. Storage space required is also closely associated with location of plant relative to source of ingredients and the capital available for equipment and building needs.

In recent years, many plants have extensively modified their receiving center to gain the economic advantages of bulk handling. Ingredients purchased in bulk are less expensive and require less manpower to receive.

Materials Received

Incoming materials can be grouped into several categories. The first and largest group--probably 60 to 75 percent of total tonnage received--may be classified as unprepared or unprocessed bulk ingredients. Into this category fall all grains which must be processed before they can be used in the manufacture of mixed feeds; also included are meat scrap in the form of cakes, fish scrap to be reground, and alfalfa pellets for grinding. All of these materials must go through processing before they are suitable for use.

The second largest group is called soft feed ingredients and accounts for about 20 to 30 percent of the total tonnage received. These may be in bulk or bags. Included in

this group are flour mill byproducts, corn milling byproducts, and various protein meals. In years past, this group was shipped in bags, which required larger warehouses, more labor, use of handtrucks, endless belt conveyors, or a palletized bag arrangement. Today these materials are generally received in bulk and unloaded with a power shovel, pneumatic system, pay-loader, conveyor under hopper cars, or truck dump. Often the worker does not touch the materials except for sampling for quality.

Another group of ingredients is the heavy materials such as minerals. These have approximately twice the density of the other ingredients, and bulk handling requires specially designed equipment. Special attention is required in engineering the handling systems and storage facilities for these materials.

Another group is the vitamins, drugs, and medications used in animal feeds today. This group receives special handling because they are expensive and the Food and Drug Administration has placed strict regulations on their storage and use. These materials are received in special containers and are handled manually. They are usually stored in a locked room where only certain persons are admitted.

Liquids have become popular in recent years. The basic liquids used are molasses, fish solubles, and fat. Recently feed manufacturers have attempted to add micro-ingredients to the mixed feeds in liquid form but this method has created many unsolved problems. Most feed plants receive these bulk liquids by rail tank car, or tank truck. Liquids are pumped from the incoming tank into storage tanks. This process requires little labor after the initial hookup.

Last of the incoming materials are feed bags, tags, string, and other miscellaneous items. These are usually stored where they are readily accessible, dry, and clean.

Materials Flow

Inbound trucks with ingredients are usually weighed on the truck platform scale. A truck hoist or dump is used for unloading bulk material from these trucks. Bulk material coming by boxcar may be unloaded by a power shovel and weighed in the mill by the automatic weight scale. Those ingredients received in hopper cars are unloaded by gravity flow and are weighed by the same scale system.

All bulk material is received through either truck or rail receiving hopper and metered evenly onto a conveyor and conveyed to the bucket elevator in the mill. Ingredients are elevated and passed through a drum magnet to remove the foreign material as it leaves the elevator. The ingredients flow by gravity over the grain-and-ingredient cleaner down through the automatic scale into the boot of another elevator, which takes the material to the top of the mill and drops it into a distributing head. This directs the material either to storage bin or into a conveyor which carries it to storage bins that cannot be filled by gravity flow.

Layout of the mill is arranged to facilitate the flow of the various materials, minimize equipment costs, and allow for future expansion. Major components are shown in figure 1. Components were selected because of the preference shown by the industry for them and because they do a good job.

To give proper specifications for equipment requires a careful evaluation of all factors. While receiving is quite similar in most feed mills, selection of equipment requires recognition of problems peculiar to a locality.

FLOW DIAGRAM FOR RECEIVING CENTER

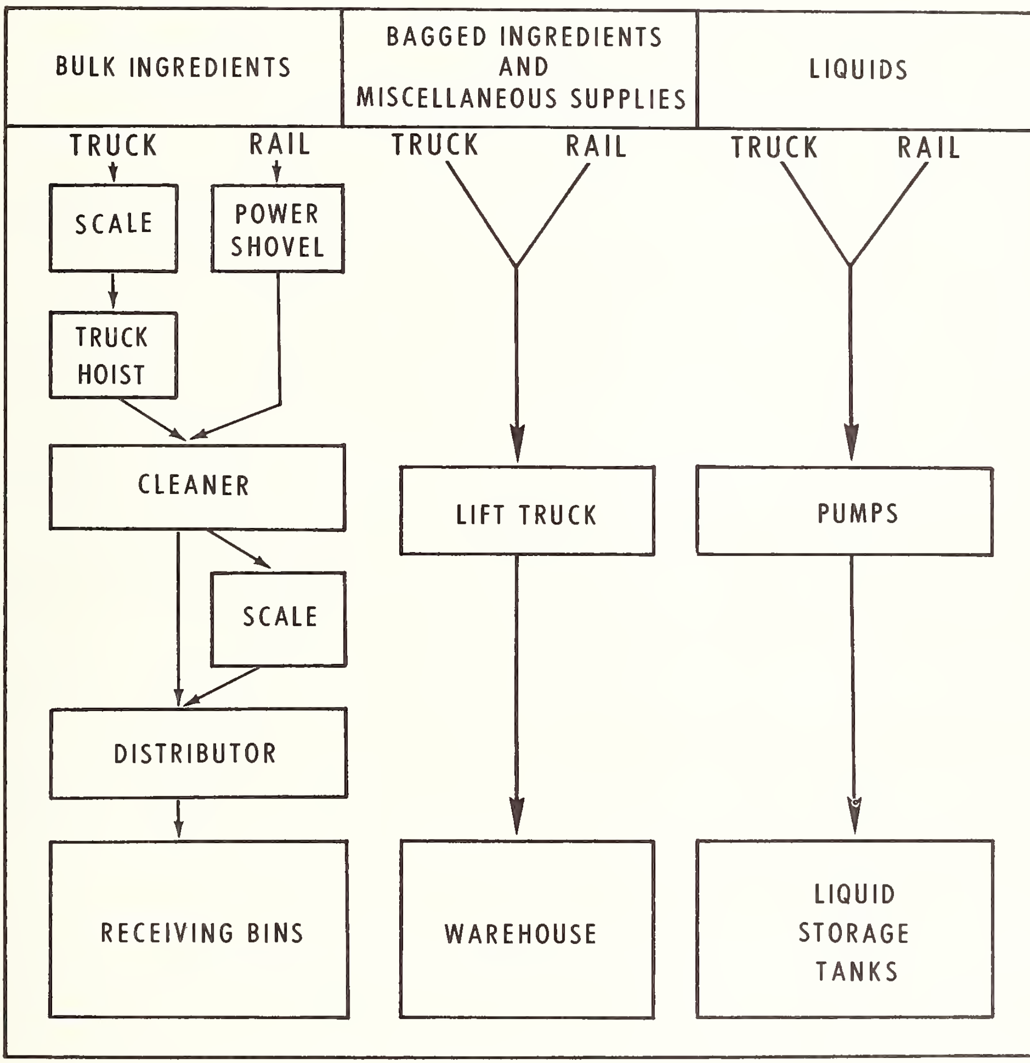

Figure 1

Oftentimes the selection of equipment in a mill is influenced by economics. The primary question is: How can materials best be moved at the lowest cost? Major factors to consider are: (1) Labor costs, (2) availability and cost of capital, (3) possibilities for expansion, (4) safety and employee relationships, (5) product contamination, (6) shrinkage control, and (7) equipment location and accessibility. Mill engineers can develop equipment layouts with a wide range in costs for a particular volume. There are numerous systems used in receiving.

Mill engineers and designers believe that a new facility should have twice the capacity needed for present demands because: (1) It will provide for better utilization of labor, (2) it will enable the mill to handle a larger volume either periodically or full time as production increases to meet demand, and (3) the larger capacity system requires small added investment.

Duties of Labor

Labor assignment and job responsibilities vary from plant to plant. However labor receiving operations common to all plants are as follows:

1. Setting up to receive rail car shipments of bulk ingredients--opening hopper or side door, setting up wind barriers, sampling, recording car seal numbers, setting receiving conveyors and elevator legs for proper bin, other preliminary work.
2. Unloading rail car--opening and closing doors on car, opening and closing dump gate to maintain uniform flow of materials.
3. Setting up to receive truck shipments of bulk ingredients--weighing, sampling, dumping or scooping, sweeping, etc.
4. Hoisting truck to unload--ingredients flow out by gravity.
5. Unloading liquids from tank car or truck--checking all tanks and pipe lines, taking meter readings of incoming and mill storage tanks, connecting and disconnecting lines from incoming tank to pump.
6. Setting up to receive sacked ingredients by rail car or truck--locating rail car or truck at unloading dock, preparing place in warehouse to stack ingredients.
7. Unloading sacks from rail car or truck--unloading and transporting them to warehouse by hand truck, forklift, belt conveyor, etc.
8. Unloading miscellaneous supplies from rail car or truck--unloading bags, tags, string, coopering paper, sanitation supplies, etc.

Other duties of the receiving center worker associated with the above items are housekeeping, miscellaneous duties such as inventory reporting and equipment inspections, and knowledge of the entire mill's production activities.

MODEL RECEIVING CENTERS

Using data from the industry survey as a basis, 2 model receiving centers were established for plants of different sizes. Estimates of receiving costs in each of the models were based on the following assumptions.

Assumptions

Both model receiving centers are set up using certain basic assumptions so that the operational standards may be established and their costs compared. The smaller

model is part of a feed mill manufacturing 80 tons of mixed feed per 8-hour day and the larger model is part of a 200-ton-a-day mill. The receiving center should handle about the same tonnage per day as the quantity of mixed feed manufactured. This tonnage may vary up to 10 percent for a given day, since bagged ingredients, miscellaneous materials, and liquids are received periodically in large quantities.

Volume of material received is broken down as a percent of total tonnage and method of delivery to the mill. Assumed receipts are as follows: 25 percent, bulk grain by rail car; 25 percent, bulk grain by truck; 25 percent, bulk soft feeds by rail car; 20 percent, bagged material by rail car and /or truck; and 5 percent, liquids by rail car and/ or truck.

Labor.--Labor used in the models is classed as production or supervisory. An average hourly wage rate of $2.05 is used for production workers on the day shift and $2.15, for the night shift workers. 1/ Supervisors' wage rate is assumed at $2.50 an hour for day shift and $2.60 an hour for the night shift. Overtime work (over 8 hours a day) is paid at time and a half.

Labor standards and rates used in this study are from a blending and updating of inplant standards of the 1956 Midwest Feed Production School. 2/ Revision of standards has been done with more recent survey data and the assistance of feed equipment manufacturers. Most of the equipment specified has hourly capacity in excess of the 8-hour day production requirements. This higher capacity is used to better utilize labor's time as well as to make up for time lost due to shutdowns and emergency maintenance.

Depreciation.--The straight-line method of depreciation is used in determining production costs for these models since it is one of the most commonly used. The initial cost plus installation cost is spread over the estimated life of the equipment. The estimated average useful life of equipment is based on rates established by the Internal Revenue Service. 3/ These estimates are averages, not minimums. Shorter lives which have already been established, or which may be justified as reflecting the mills' existing or intended replacement practices, will be permitted. These new guidelines procedures should not replace below-guidelines lives which have been demonstrated as realistic. Mill management may want to establish shorter tax lines concurrent with adoption of more progressive replacement and modernization practices.

Building depreciation is not estimated for the models because space necessary for receiving center equipment and storage facilities varies widely depending on locality and type of production schedule in the plant.

Electricity.--An average charge of 3.25 cents per kilowatt-hour is assumed. This straight-line method is used because previous studies have shown that total cost for electricity increases in direct proportion to increase in tonnage.

Electricity cost is estimated on the basis of the assumed rate, the average time required for the equipment to handle the materials, and normal power use by equipment. If machines are stopped when not in use, electricity costs and the wear on various parts are reduced. This practice also adds to the safety of the workers.

Interest.--Annual interest cost is estimated by applying 3 percent, or one-half the nominal interest rate of 6 percent, times the total capital investment in equipment.

1/ Bureau of Labor Statistics, U. S. Department of Labor. Employment and Earning, 1964.

2/ Proceeding of the 1956 Midwest Feed Production School, Dec. 1956.

3/ U.S. Internal Revenue Service. Depreciation--Guidelines and Rules. Pub. No. 456.

Interest is an imputed cost which does not take into account the source of investment capital. Although business firms usually show interest as an expense only if paid to outside agencies, true capital cost includes an interest allowance on the owners' equity.

Interest cost for building space is not calculated because of the wide range of capital investment possible. It is possible to find 2 plants of the same capacity where the capital investment in 1 is two-thirds more than in the other. There are numerous factors which determine the type and size of plant.

Maintenance.--Maintenance costs are estimated for labor needed to keep the equipment in running condition and include time for both minor and major repairs as well as for preventive maintenance, such as greasing, oiling, and adjustment to equipment during normal operations. Wage rates for maintenance workers are $2.35 per hour for day-shift and $2.45 an hour for the second-shift workers.

No attempt is made to estimate cost of parts and other materials required in repairing equipment. An estimate could range between 1.5 percent to 3 percent of initial cost. Variations in types of equipment, preventive maintenance programs, and maintaining a parts inventory are some of the factors influencing the percentage used.

Maintenance on building space occupied by the receiving center is difficult to estimate. Maintenance is considered by many as a nonproductive cost such as housekeeping. However, these costs should be fixed to the appropriate center as a cost of operation. Where maintenance practices are inadequate in feed mills, the cost is usually high. Management is attempting to use more automation and mechanization where economically feasible. Because of this, maintenance needs are increasing and it is advantageous to management to keep costs down through preventive maintenance and other cost reduction techniques.

Small Mill

The small model receiving operation is part of a feed mill which manufactures 80 tons of mixed feeds per 8 hours. About 40 tons of grain are received per 8-hour day--one-half by rail car and one-half by truck. Another 25 percent of the total, or 20 tons, of bulk soft feeds are received by rail car. The remaining 16 tons of bagged materials arrive in either rail car or truck. Liquids accounting for about 5 percent of the total ingredients received may be in tank car or truck.

Equipment Cost

Equipment used in this receiving center costs about $64,280 installed (table 1). Installation cost would be approximately $18,320, or 40 percent of the equipment cost. About 30 percent of this cost is for basic conveying equipment. The remaining 70 percent is for equipment for weighing and for handling liquids.

The truck scale and truck hoist cost about $8,540 each and are important particularly because of the increasing quantity of local ingredients purchased in bulk form. Truck scales are also useful for weighing bulk trucks delivering the finished product.

An electrically operated, manually guided power scoop made of light metal is used to unload boxcars. This power shovel is also used by many mills to unload bulk trucks.

Table 1.--Number, capacity, and cost of equipment used in model center receiving 80 tons of feed ingredients per 8-hour shift

Equipment 1/	Quantity	Capacity	Approximate cost installed
	Number		Dollars
Truck scale, 10' x 50' w/dial printer	1	50 tons	8,540
Truck hoist, 15 hp	1	25 tons	8,540
Power shovel, 7 ½ hp	1	1,500 bu./hr. 30 tons/hr.	1,820
Receiving conveyor, drag 12' x 75' 15 hp	1	1,500 bu./hr. 30 tons/hr.	4,900
Receiving elevator 60' x 75' 7½ hp	1	1,500 bu./hr. 30 tons/hr.	4,480
Drum magnet, 15" x 24", 1/3 hp	1		2,660
Grain and soft ingredient scalper, with suction head, 1 hp	1	1,500 bu./hr. 30 tons/hr.	3,780
Automatic dump scale, surge bins (inlet and outlet) with dial and printer	1	2,000 bu./hr. 40 tons/hr.	8,260
Receiving elevator, 100', 10 hp	1	1,500 bu./hr. 30 tons/hr.	6,300
Conveyor, Drag 12" x 45' 7½ hp	1	1,500 bu./hr. 30 tons/hr.	3,920
Receiving distributors, manual, turn-head type--			
10" x 6-hole, grain	1		560
10" x 11-hole, soft ingredient	1		980
Forklift truck 2/	1	1 ton	1,600
Pumps, liquid 3½ hp. and 7½ hp	2	2,000 gal./hr.	1,540
Tanks, liquid	2	10,000 gal.	5,600
Boiler (steam) 3/	-	40 hp.	800
Total equipment cost			64,280

1/ Each item of equipment listed is complete with all accessories and parts necessary for complete installation.
2/ No installation charge.
3/ Prorated on basis of percentage of plant's steam needed to heat liquids. The original cost of the boiler including installation is about $8,000.

The horizontal drag conveyor carries materials received by truck and by rail into the mill to the receiving bucket elevator. A drag conveyor is used to move the materials horizontally because of its self-cleaning ability. Although there are other types of horizontal conveyors, use of this type is increasing.

The 2 receiving elevators, costing about $10,780, are used to (1) elevate material to the cleaner and the automatic scale and then (2) move these materials to the top of storage tanks. These elevators may be outside and should be of heavy construction, weather and air tight, and of the floating boot type to eliminate contamination. There should also be a clean-out door in the base of each elevator.

A grain and soft-ingredient cleaner is important. Its purpose is to remove with air foreign and over-size materials or dust from the incoming feed ingredients. A drum magnet which removes iron and steel material from the incoming ingredients is also used. This is a revolving shell within a bank of stationary magnets. The nonmetallic material falls off the drum as it revolves part way, and as the drum makes a complete cycle it passes out of the magnetic field and the metallic scraps are dropped into a container. Metal of this type in a feed system is feared because of fire and damage to equipment.

An automatic weighing scale is becoming increasingly important. With it the mill management is able to check the weights of all incoming ingredients, particularly rail shipments. An automatic cycling batch scale with surge hoppers before and after the scale is included in the model. The scale may be set for a particular weight, and the unit will weigh and count the number of times the scale is tripped. This scale has either automatic or manual control operations.

Another drag conveyor is used in the model to convey materials from the top of bucket elevator over the storage bins. The materials drop into 1 of 2 receiving distributors.

A 6-hole distributor is used for grains and an 11-hole distributor, for soft ingredients. The function of this turnhead type of distributor is to receive ingredients from the drag conveyor and to distribute them into specific bins. These distributors are manually operated. However, some feed mills have electrically controlled distributors which an operator unloading material from a rail car or truck can automatically set from the unloading area. Pushbutton starters, bin-selector lights, bin labels, etc., are usually installed with this type of equipment at the unloading point. These electrically controlled distributors would cost approximately $1,500 each installed.

The liquid receiving equipment for the 2 separate systems in the 80-ton mill costs about $7,140. These are used for fat and molasses. Each system consists of 1 pump and 2 tanks. Tank size and number are usually based on number and volume of liquids handled. Tank capacity when possible should be at least 1 1/2 times the maximum delivery for each liquid. It is recommended that mills have at least 2 tanks for each type of liquid used in order that: (1) A new load can be tested before it is used and (2) the existing liquid can be completely emptied and the tank cleaned. This prevents an accumulation of sludge in molasses or rancidity in fat.

The last major piece of equipment used is the forklift truck with a 1-ton capacity. It has been allocated a cost of $1,600 in this center. About 2.6 hours per day are required for the forklift to unload sacked ingredients, empty bags, and miscellaneous items received. All sacked incoming ingredients are unloaded from the rail car

onto pallets, which are transported into the warehouse for storage. The remaining 5.4 hours of the forklift's time are divided between the mixing and the warehousing cost centers.

Operating Cost

The total annual operating cost for the small model receiving center is $13,241, or approximately 64 cents per ton (table 2).

Labor.--Annual production labor cost is $3,710 for this model, and supervisory labor cost, about $1,014 (table 2). About 6.96 production man-hours are required for each 8-hour shift. Supervisory time is allocated at 1.5 man-hours per shift. Total production and supervisory labor requirement is .11 man-hour per ton of material handled (table 3).

Unloading bulk grain from a truck is a quick operation. The front of the truck is hoisted by the operator and the material is unloaded by gravity flow.

Unloading liquid ingredients is another operation which requires few man-hours. The operator couples the tank outlet of the rail car or truck to the storage tank with a flexible hose, turns on the pump, checks the flow, and then may go on to another task. Liquid loads usually range in weight from 15 to 30 tons. It is assumed that about 4 tons, or 5 percent of the tonnage handled in 1 day is liquid. Therefore, the time required to unload 4 tons, .05 man-hour for an 8-hour shift, is allocated to each day's labor requirements.

Depreciation.--The annual depreciation for the equipment in the model is about $3,943 (table 2). Average life of most feed mill equipment is 17 years. However, some equipment such as the forklift has a shorter life of 10 years, while the truck scale and hoist have a longer life of 25 years.

Electricity.--Total annual electricity cost for this model is relatively small, about $1,167 (tables 2 and 4). In this operation are 11 motors, with a total of 73 1/3 horsepower. The receiving conveyor used to convey the bulk material from truck and rail pits uses approximately one-third of the total electricity consumed.

Interest.--Interest on the equipment in this center is $1,928 (table 2). In determining the annual cost of interest, a nominal rate of 6 percent is charged on one-half the original capital investment.

Forklift truck.--A 1-ton forklift is used to carry the bagged material on pallets from rail car or truck at receiving dock to the warehouse storage area. Twenty 100-pound bags or 40 50-pound bags are loaded onto each pallet. These pallets may be stacked 2 or 3 high depending on warehouse space and needs. A 1-ton forklift costs from $4,400 to $6,400. There are 3 basic types of trucks available: gasoline, LP gas, and electric driven (listed in ascending order of cost). About 2.6 hours of the forklift's time is used by the receiving center each day. An average of $1,600 for the forklift truck cost is allocated to this center. At an estimated cost of 50 cents per hour, the annual cost is about $338 (table 2). This is an average cost and varies between plants because of differences in operating conditions and in maintenance programs and care. A careful operator can help to extend the life of machinery or equipment.

The operating cost per hour is about 50 cents which includes fuel and maintenance. Fuel cost accounts for 40 to 50 percent of this total. A gasoline driven forklift tends to have the highest hourly fuel cost.

Table 2.--Operating costs for model center receiving 80 tons of feed ingredients per 8-hour shift

Item	Cost per year	Cost per ton
	Dollars	Cents
Labor:		
Production	3,710	18
Supervisory	1,014	5
Depreciation 1/	3,943	19
Electricity	1,167	6
Interest 1/	1,928	9
Forklift truck 2/	338	2
Fuel (steam)	225	1
Maintenance	916	4
Total	13,241	64

1/ For equipment only.
2/ Cost of 50 cents per operating hour is used which includes fuel and maintenance costs.

Table 3.--Estimated labor requirements for model center receiving 80 tons of feed ingredients per 8-hour shift

Job	Labor standards (man-hours)	Quantity per shift	Man-hours per shift	Man-hours per ton
Bulk grain RR car	.033 per ton	20 tons	.66	
Bulk grain truck	.033 per ton	20 tons	.66	
Bagged ingredient, RR car or truck	.125 per ton	16 tons	2.00	
Bulk soft feed, RR car	.067 per ton	20 tons	1.34	
Empty bags, etc		10 min./day	.17	
Liquid ingredient 1/	.012 per ton	4 tons	.05	
Move cars, clean up, weigh, and change spouts		3/4 hr./day	.75	
			5.63	
Allowance 2/			1.13	
Total production labor			6.96	.09
Supervisor	1.5 hrs.		1.50	.02
Total labor			8.46	.11

1/ Time required to unload the quantity used in 1 shift.
2/ 20 percent of time allowed for workers' personal requirements.

Table 4.--Electric power: Annual requirements and costs for model receiving 80 tons of feed ingredients per 8-hour shift 1/

Equipment	Rated horsepower	Kilowatt input 2/	Hours operating	Electric power per year: Use 3/	Electric power per year: Cost 4/
	Number	Kilowatts	Number	Kw. hr.	Dollars
Truck hoist	15	13.20	.79	2,712	88
Power shovel	7½	6.70	2.40	4,181	136
Receiving conveyor	15	13.20	3.19	10,949	356
Receiving elevator	7½	6.70	3.19	5,556	181
Drum magnet	1/3	0.35	3.19	291	9
Grain and ingredient scalper	1	0.95	3.19	528	17
Receiving elevator	10	8.78	3.19	7,283	237
Drag conveyor	5	4.47	3.19	3,708	120
Pump:					
Molasses	7½	6.70	.05	88	3
Fat	3½	3.25	.02	16	1
Boiler 5/	1	0.95	2.40	593	19
Total	73 1/3			35,905	1,167

1/ Assume motors are correctly sized and will operate at full-load condition.
2/ Kilowatt inputs for induction motors: Rogers, Price L. Power Factor Economics. John Wiley & Sons, Inc., New York, p. 23-25, 1939.
3/ Kilowatt hours (kw. hr.) = number of hours operating per day x kw. input x number of operating days (260).
4/ Average cost per kw. hr. used was 3.25 cents, used in previous studies.
5/ Estimated electricity used by boiler in heating liquids.

Fuel.--Fuel cost for this model is estimated at about $255 (table 2). Steam is required for heating the liquids as they are unloaded and to maintain a temperature level while in storage. Allocation is based on amount of steam used in this center as related to that used by other centers.

Maintenance.--About 390 maintenance man-hours for equipment are needed annually in this receiving center. Maintneance workers spend about 15. man-hours per day there. Assuming an average wage rate of $2.35 per hour for maintenance workers, the annual maintenance cost is approximately $916 (table 2).

Large Mill

The larger model receives and unloads 160 tons of bulk ingredients each 8-hour shift. Bulk received is broken down into grains, soft feeds, and liquids. One hundred tons of bulk grain received is equally divided between rail car and truck. Fifty tons of soft feeds are received by rail car; and liquids, the remaining 10 tons, are in either tank rail car or tank truck. Bagged ingredients make up about 20 percent, or 40 tons, of the total amount received. Empty bags and miscellaneous items complete the materials received.

Equipment Cost

Total cost including installation of equipment for this model is $101,110 (table 5). This figure includes a 40-percent installation charge. This may be high for certain pieces of machinery which are complete units and do not require extensive time and material for piping, electrical, or other installation work. However, these compensate for other equipment which costs more to install. Purchase cost of equipment is about $72,500.

A truck scale is used to weigh local ingredients shipped in by truck and is frequently used to weigh outshipments of bulk finished feeds. A truck scale with capacity of 50 tons costs approximately $8,540, installed. A truck platform dump is used to elevate the truck so that the material flows by gravity. It is the most expensive item and costs $18,620, about 19 percent of the total cost.

In this large model receiving center 2 power shovels are used to unload bulk rail cars which cannot be unloaded by gravity-flow into the receiving hopper. A receiving conveyor of the drag type is located under both the truck and rail unloading hoppers. In a 1-system mill such as these models, it is necessary to have equipment of proper size and self-cleaning. A disadvantage of a system of this type is that only one bulk material can be unloaded at any one time.

Bulk materials are conveyed to the boot of the first elevator which lifts either the grain or soft feed ingredients at the rate of 2,000 bushels, or 40 tons per hour. The material is taken to the top of the elevator where it is discharged to pass through a drum magnet, similar to that used in the smaller mill. At this point, the material flow can be directed through the automatic scale or to 1 of the 2 scalper-cleaners.

An automatic scale, costing about 8 percent of the total cost of the plant's equipment, is also included for check weighing of bulk ingredients received in rail cars.

Soft feeds are sent over the scalper which removes paper, sticks, lumps, kernels of grain, etc. The flow of grain is diverted to the grain cleaner for removal of corn

Table 5.--Number, capacity, and cost of equipment used in model center receiving 200 tons of feed ingredients per 8-hour shift

Equipment 1/	Quantity	Capacity	Approximate cost installed
	Number		Dollars
Truck scale, 10' x 50' w/dial printer..	1	50 tons	8,540
Truck dump, platform 2-20 hp...........	1	50 tons	18,620
Power shovels, 7½ hp..................	2	2,000 bu./hr.	2,800
Receiving conveyor, drag 12" x 60', 7½ hp..............................	1	2,000 bu./hr. 40 tons/hr.	4,200
Receiving elevator 100', 10 hp.........	1	2,000 bu./hr. 40 tons/hr.	6,300
Drum magnet, 15" x 24", ½ hp...........	1		2,660
Soft ingredient scalper, 1 hp...........			3,850
Grain cleaner, 10 hp..................	1	2,000 bu./hr. 40 tons/hr.	7,140
Automatic dump scale, surge bins (inlet and outlet) with dial and printer....	1	2,000 bu./hr. 40 tons/hr.	8,260
Receiving elevator 135', 15 hp.........	1	2,000 bu./hr. 40 tons/hr.	5,320
Conveyor, drag 16" x 40', 7½ hp........	1	2,000 bu./hr. 40 tons/hr.	3,780
Conveyor, drag 16" x 30', 7½ hp........	1	2,000 bu./hr. 40 tons/hr.	3,220
Receiving distributors, manual, turn-head type--			
10" x 6-hole grain.................	1		560
10" x 12-hole soft ingredient.......	1		980
Horizontal capstan car puller w/rope and hook, 7½ hp.....................	1	5 55-ton cars	1,680
Forklift truck 2/.....................	1	1½ tons	4,800
Pumps, liquid, 3 hp. and 15 hp.........	2	4,000 gal./hr.	2,800
Tanks, liquid.........................	5	10,000 gal.	14,000
Boiler (steam) 3/.....................	-	100 hp.	1,600
Total equipment cost................			101,110

1/ Each item of equipment listed is complete with all accessories and parts necessary for installation.
2/ No installation charge.
3/ Prorated on basis of percentage of plant's steam used to heat liquids. The original cost of the boiler including installation is about $16,000.

cobs, straw, and other foreign matter. There is some tendency for these pieces of equipment to be eliminated in the newer mills; however, it is recommended that such equipment be used.

Once more the cleaned grains and soft feeds are elevated to the bin floor. There they are sent over the storage bins in a drag conveyor, which is self-cleaning and can be used for both grains and soft feeds. The materials are discharged into 2 drag conveyors--1 for grains and 1 for soft feeds. Total cost of these conveyors is $7,000. The conveyors discharge into distributors which direct the flow of materials into their respective storage bins. These receiving distributors are similar to the 2 used in the smaller model. Turn-head distributors are recommended for distribution of materials flowing from one source to a number of receiving bins. Remote controls for distributors might be advisable for a mill of this size, however those in this model are manually operated. Many pieces of equipment may be automated but the degree of automation depends on management's decision which is influenced by capital available, cost of labor, etc. A remote controlled distributor would cost about $1,500.

A capstan car puller saves labor and is necessary for a mill of this size. With this puller a worker can move up to 4 loaded railroad cars at a time, using a Manila or marline-covered-wire rope. One man can easily move cars on and off the unloading pit as needed.

Two liquid systems are assumed to be necessary in this model. A molasses and a fat system are common with most mills this size today. Total cost for the receiving portion of these systems is approximately $16,800, for pump, tanks, and necessary piping. Costs of these systems depend on type of liquid pumped, temperature at which it is kept, height of lift from rail car or truck, and number and size of storage tanks.

A 1 1/2-ton forklift truck is one of the major pieces of equipment in the receiving center, and may be used by several centers. Receiving and warehousing operations use this equipment almost 100 percent of the time. Since the truck is used about 6 hours in an 8-hour shift, only that proportion of its cost and expenses are allocated to receiving center. About two-thirds of the original cost of $7,000 is obligated to this operation. Therefore, $4,800 is assumed as the initial cost.

Operating Cost

Total operating costs for the larger model are $25,362 (table 6). Individual cost items are given in more detail in tables 7 and 8.

Labor.--Production labor for this model which handles 200 tons of ingredients per 8-hour day is 14.11 man-hours (table 7). Unloading bagged ingredients takes 36 percent of total labor time, however bagged material accounts for only 20 percent of total amount received. This is an important factor which has led to the increased use of bulk ingredients. A feed plant of this capacity can efficiently purchase and handle practically all raw ingredients in bulk form.

It is difficult to predict whether ingredients will come into plant by rail or by truck. In the model it is assumed that incoming shipments of the various ingredients are equally divided between rail and truck. Liquids and miscellaneous bagged materials are received in truck load or car load quantities; however, daily use is assumed to be amount received in any 1 day. Often, cars and trucks arrive at the same time for unloading, making it advisable to keep the work crew flexible as to assignments.

Table 6.--Operating costs for model center receiving 200 tons of ingredients per 8-hour shift

Item	Cost per year	Cost per ton
	Dollars	Cents
Labor:		
Production	7,521	14
Supervisory	2,028	4
Depreciation 1/	6,540	13
Electricity	3,187	6
Interest 1/	3,023	6
Forklift truck 2/	780	2
Fuel (steam)	450	1
Maintenance	1,833	4
Total	25,362	50

1/ For equipment only.
2/ Cost of 50 cents per operating hour is used, which includes fuel and maintenance costs.

Table 7.--Estimated labor requirements for the model center receiving 200 tons of feed ingredients per 8-hour shift

Job	Labor standard (man-hours)	Quantity per shift	Man-hours per shift	Man-hours per ton
Bulk grain, RR car	.033	50 tons	1.65	
Bulk grain, truck	.025	50 tons	1.25	
Bagged ingredient, RR car or truck	.125	40 tons	5.00	
Bulk soft feed, RR car	.067	50 tons	3.35	
Empty bags, miscellaneous items		30 min./day	.50	
Liquid ingredient 1/	.01	10 tons	.08	
Move cars, change spouts, weigh, and clean up		1 hr./day	1.00	
Allowance 2/			1.28	
Total production labor			14.11	.07
Supervisor	3.0 hr.		3.00	.02
Total labor			17.11	.09

1/ Time required to unload the quantity used in 1 shift.
2/ 10 percent of time allowed for workers' personal requirements.

Table 8.--Electric power: Annual requirements and costs for model center receiving 200 tons of feed ingredients per 8-hr. shift

Equipment	Rated horsepower	Kilowatt input 2/	Hours operating	Electric power per year: Use 3/	Electric power per year: Cost 4/
	Number	Kilowatts	Number	Kw. Hr.	Dollars
Truck dump	40	33.30	.55	4,763	155
Power shovels	15	13.20	5.50	18,876	614
Receiving conveyor	7½	6.70	6.87	11,968	389
Receiving elevator	10	8.78	6.87	15,683	510
Drum magnet	1/3	0.35	6.87	624	20
Ingredient scalper	1	0.95	3.70	915	30
Grain cleaner	10	8.78	3.20	7,306	238
Receiving elevator	15	13.20	6.87	23,577	766
Drag conveyor	7½	6.70	3.20	5,574	181
Drag conveyor	7½	6.70	3.70	6,445	209
Car puller	7½	6.70	.30	523	17
Pumps:					
Molasses	15	13.20	.12	411	13
Fat	3	2.80	.05	36	1
Boiler 5/	1	0.95	5.50	1,360	44
Total	140 1/3			98,061	3,187

1/ Assume motors are correctly sized and will operate at full-load conditions.

2/ Kilowatt inputs for induction motors: Rogers, Price L. Power Factor Economics. John Wiley & Sons, Inc., New York, pp. 23-25, 1939.

3/ Kilowatt hours = number of hours operating per day x kw. input x number of operating days (260).

4/ Average cost per kw. hr. used was 3.25 cents, used in previous studies.

5/ Estimated electricity used by boiler in heating liquids.

Annual production labor cost for this model is $7,521 (table 6). Supervisor's time allocated to this center is 3 hours per 8-hour operation. At the assumed average wage rate, annual supervisory cost is $2,028. The supervisor must direct and coordinate activities of the receiving crew in order to meet production requirements of other cost centers. He is directly responsible for quality of materials unloaded as well as quantity received in the mill.

Depreciation.--Annual depreciation cost for this model is $6,540 based on equipment cost of about $101,110 (table 6). Most of the equipment has an average useful life of 17 years. Some equipment depreciation has been estimated at a higher or lower rate because its useful life was found to be different from the average.

Electricity.--Approximately 98,061 kilowatt hours of electricity are used in this receiving model (tables 6 and 8). At the assumed rate per kilowatt hour, total cost would be about $3,187, or about 15 percent of total receiving cost.

Interest.--Interest cost for the model is estimated to be about $3,023 (table 6). This cost accounts for about 12 percent of total annual operating cost for model.

Forklift truck.--In this model a 1 1/2-ton capacity forklift is used. Costs of 3 basic types of truck with this capacity range between $6,000 and $8,000. A cost of $4,800 has been allocated for this center.

Operating cost for this forklift is about the same as for the 1-ton model used in smaller model. A gasoline-driven truck may be slightly more expensive to operate, however, costing an average of 50 cents per hour. Therefore, the annual cost of fuel and maintenance should be about $780 (table 6).

Fuel.--This model center will use about $450 in fuel to heat liquids received and stored (table 6). Allocation was made on estimate of steam used, as was done in smaller model.

Maintenance.--Annual maintenance labor cost for the model is $1,833 (table 6). In a feed plant of this size, maintenance of equipment for receiving center should take about 3 hours for an 8-hour shift.

VOLUME COST RELATIONSHIP

The 2 models in this study are typical of receiving centers in feed plants throughout the industry. When the models were constructed, certain assumptions were made. A primary assumption was that they operate 8 hours a day, 260 days a year. Assuming this, it is estimated that the smaller model center handles about 21,000 tons annually, and the larger model about 52,000 tons. Quantity could be about doubled to compare it with many feed plants which operate 2 shifts a day. The second shift would require the same size of work force as the first shift.

To make this comparison, the models' costs have been expanded to full second shift operations (table 9). The second shifts are assumed to have the same basic production schedules as those in the 1-shift models. Production, supervisory, and maintenance labor accounts for 42 to 44 percent of total cost in each plant when working only 1 shift. If each model operates 2 shifts, then labor accounts for a larger percentage of cost. Variable costs, primarily labor, become a greater part of total cost as number of shifts are increased.

Table 9.--Annual operating costs for model feed receiving centers: Small versus large, operating 1 and 2 shifts

	Small model				Large model			
	1 shift		2 shift		1 shift		2 shift	
	Cost per ton	Percentage of total	Cost per ton	Percentage of total	Cost per ton	Percentage of total	Cost per ton	Percentage of total
	Cents	Percent	Cents	Percent	Cents	Percent	Cents	Percent
Labor:								
Production	18	28	18	36	14	28	15	36
Supervisory	5	8	5	10	4	8	4	10
Depreciation	19	30	10	20	13	26	6	15
Electricity	6	9	5	10	6	12	6	15
Interest	9	14	5	10	6	12	3	7
Forklift truck 2/	2	3	2	4	2	4	2	5
Fuel (steam)	1	2	1	2	1	2	1	2
Maintenance	4	6	4	8	4	8	4	10
Total	64	100	50	100	50	100	41	100

1/ Estimated operating cost for 2 8-hour shifts, 260 days a year. Labor costs have been adjusted with differentials for night shift.

2/ Cost of 50 cents per operating hour is used, which includes fuel and maintenance costs.

Using basic operating costs in table 9 for the 2 model receiving centers, it is noted that the smaller model, working 16 hours a day, can handle a ton of ingredients at a cost of 50 cents. This is equal to the cost per ton for the basic larger model. Equipment in smaller model is about 64 percent of equipment cost for larger model. A 36-percent difference in capital investment for this one operation of the mill indicates management should make a closer review of alternatives.

Management should seriously consider the feasibility of a small plant operating more than one shift a day. This means greater utilization of facilities, and allows management to recover initial investment more rapidly. With variable costs, such as labor, exerting more pressure on cost per ton, management leans more toward automation. Capital invested increases with automation; however, in areas of high labor cost, management gives more consideration to this alternative.

Automation does not necessarily mean lower labor cost. However, it provides certain controls for product quality and inventory management. All segments of this type of system are interlocked so that every part of the system has to function properly. Automation reduces human errors, thus reducing time needed to correct them.

The cost of ingredients handling is influenced greatly by the proportion of materials received in bulk. As this proportion increases, equipment is more fully utilized. Table 10 provides a cost comparison for the models when they receive 50 and 100 percent of materials in bulk, as contrasted to 80 percent. There is definite savings with bulk.

Table 10.--Receiving feed ingredients:--Cost per ton for the 2 models as influenced by percentage of bulk

Percentage received in bulk	Small model: Cost per ton	Large model: Cost per ton
	Cents	Cents
50 percent	66	53
80 percent	64	50
100 percent	61	47

If the models are assumed to receive around 50 percent in bulk, the cost per ton is about 3 percent higher in the small model and 6 percent higher in the larger. On the other hand, if 100 percent is assumed to be received in bulk, the smaller model's cost per ton is about 5 percent less, while the larger model's cost per ton is 6 percent less. These per ton costs increase or decrease mainly because of costs for production labor and forklift trucks. In the final analysis, this reflects the savings possible through more efficient handling and better utilization of equipment.

There are several important reasons why percentage of bulk received has not increased more rapidly for all mixed feed manufacturers. Before a feed mill goes to nearly 100 percent bulk handling, management must ask: (1) Are there a sufficient number of bulk storage bins with adequate capacity and (2) will existing equipment be able to handle bulk ingredients of varying densities? The densities of different ingredients can vary so widely that new equipment may be necessary to handle certain materials in bulk.

Management may finally decide that bulk handling would require an extensive renovation of facilities. New storage facilities with an adequate unloading system

could be costly. Management must also determine if bulk ingredients can be purchased from present sources.

Many manufacturers prefer to receive bulk in hopper rail cars; however, not all suppliers have this type. This is the best way to receive bulk material since fewer man-hours are required for unloading, and this means savings, leading to lower ingredient costs.

METHODS OF HANDLING INGREDIENTS

Ingredient handling in mixed-feed plants has undergone a major change in recent years. Mills have changed from bagged ingredients to bulk ingredients whenever possible. The survey plants have illustrated that there is still a wide range in the quantity of bulk received by individual mills. Also there are many combinations of equipment used in handling materials. However, industry uses but few basic handling methods.

Mechanical

Feed mills use various types of mechanical conveying equipment to move materials. Due to the wide variety of materials being conveyed, great care must be given to the selection of the proper conveyor.

There is a large variety of horizontal mechanical conveyors; however, the 4 major types in use are: screw conveyors, drag conveyors, belt conveyors, and vibrating conveyors. The physical characteristics of the material to be handled should determine the type of conveyor that is selected. The most important of these characteristics are size of granulation and whether the material is abrasive or corrosive. Other important characteristics are its weight per cubic foot and whether it flows readily. After these characteristics are known, the decisive factors, which will eliminate those conveyors not capable of doing the job, are length of conveyor and type of service--indoor or outdoor and continuous or intermittent.

Vertical conveying in most feed mills is done by bucket elevators. A bucket elevator consists of an endless belt to which are attached buckets which elevate the various materials. Bucket elevators handle practically all loose materials, but light, fluffy materials sometimes cause problems. Bucket elevators should be operated vertically; however, some plants use them in a steeply inclined position. This is a special type of installation and requires idlers or supporting rails along the loaded run of the elevator.

In selecting a vertical conveyor, the feed manufacturer again must know the characteristics of the materials to be handled. There are numerous types and variations of equipment which management can select as the most suitable for the job.

Pneumatic

Pneumatic or air handling is one of the fastest growing methods of material handling. There are 3 basic types of air systems used by the feeds industry: Negative pressure, positive pressure, and a combination of these. Negative pressure units pick up materials at many points along the system and discharge them at one point through a rotary valve. A positive pressure unit is fed at one or more points through precision

built feeders and can discharge the materials at several points, to settling collector or direct to bins. A combination system combines the principals of the negative and positive pressure systems into one system.

In selection and application of a pneumatic system, characteristics of materials to be handled are again major items to consider. A negative pressure system is applicable where the inlet is movable as in a rail car or truck. And if only a small capacity system is needed, it is less expensive than a positive pressure unit.

However, if there is more than one inlet point to a system with multiple distribution points, a positive or a combination system is more advantageous. When a high pressure system is used, the operation is usually more efficient and smaller; and less expensive smaller pneumatic conveying tubes are used.

Pneumatic systems have been used by the mixed feeds industry in bulk truck delivering feed to the farm. The truck operator couples a flexible tube on the stationary tubing and delivers the feed to the storage bin. Some bulk delivery trucks use a combination negative pressure system which provides greater flexibility since it can be used to both pick up and deliver materials.

A pneumatic system, as other systems, has advantages and disadvantages. Some of the advantages are: Ease of installation, self cleaning, that it lends itself to automation, fewer moving parts, and that it eliminates dust from the materials handling. The major disadvantages are: Frequently higher initial cost, higher power requirements, and that more care is required in designing and operating for maximum efficiency.

Pneumatic systems must be designed by specially trained engineers in order to operate efficiently. Also, in operating a pneumatic system, the worker must follow certain practices to obtain maximum results. For example, if a flexible hose with a nozzle is used to unload soft feeds from a bulk rail car, particular care must be taken.

Cost of Operating Comparable Handling Systems

Management must consider many factors in selecting a materials handling system, including advantages and disadvantages as well as cost. Pneumatic systems are being used more and more by the feeds industry, both for ingredients handling and for the finished products. In addition, there are advantages to a pneumatic system which handles one particular product.

To serve as a guide for management in evaluating a system, a comparsion is made between the operating costs of those models using a mechanical system and those using an alternative method. Tables 11 and 13 show requirements for alternative systems which handle about the same tonnage as the 2 models. The equipment lists differ from the models mainly in that they include pneumatic equipment which replaces mechanical. Pneumatic equipment is required to move incoming bulk ingredients from rail car or truck, through cleaning and weighing operations, to bulk storage bins above the mixing operation.

The alternative system using pneumatic conveyor is suitable for unloading bulk ingredients in the 80-ton mill model and would cost about $54,780 installed (table 11). The 80-ton model's equipment cost is about 17 percent higher than that for the pneumatic system. Installation costs have been estimated at 40 percent of equipment cost. However, it is possible that installation of pneumatic equipment could cost more

Table 11.--Equipment, capacity, and cost of alternative system for model center receiving 80 tons of feed ingredients per 8-hour shift

Equipment 1/	Quantity	Capacity	Approximate cost installed
	Number		Dollars
Truck scale, 10' x 50' with dial printer	1	50 tons	8,540
Negative pressure blower assembly 60 hp. 70' lift, 40' run, 4 90° ells	1	20 tons/hr.	5,880
Collector-airlock, 2 hp.	1	20 tons/hr.	3,500
Hopper car manifold	1		420
Unloading nozzle	1		420
Piping			2,240
Magnetic drum, 15" x 24", 1/3 hp.	1		2,660
Grain and soft ingredient scalper with suction head, 1 hp.	1	2,000 bu./hr.	3,780
Automatic dump scale, surge bins (inlet and outlet) with dial and printer	1	40 tons 2,000 bu./hr.	8,260
Positive pressure blower assembly 30 hp.	1	2,000 bu./hr. 40 tons/hr.	4,760
Airlock and manifold 2 hp.	1		3,080
Piping			1,460
Switch station	1		240
Forklift truck 2/	1	1 ton	1,600
Pumps, liquid, 3½ hp. and 7½ hp.	2	2,000 gal./hr.	1,540
Tanks, liquid	2	10,000 gal.	5,600
Boiler (steam) 3/	---	40 hp.	800
Total equipment cost			54,780

1/ Each item of equipment listed is complete with all accessories and parts necessary for complete installation.
2/ No installation charge.
3/ Prorated on basis of percentage of plant's steam needed to heat liquids. The original cost of the boiler including installation is about $8,000.

or less than that for a mechanical system. An estimate can vary with the installation as well as with geographic location. The capacity of the pneumatic system selected for this smaller model is not equal to the mechanical system. This is because a larger system would require more horsepower and would increase the handling cost per ton of material. This smaller capacity system requires more manpower than the model using a mechanical system.

In table 12 are shown the annual operating costs of the model and the alternative system which handle 80 tons a day. The pneumatic system would have a total annual cost approximately 17 percent higher than the straight mechanical system. Cost of electricity and depreciation are the major factors in the higher costs.

Maintenance cost is an area of varying opinions, where many figures are quoted concerning different systems. However, those who are unbiased and work with both

Table 12.--Operating costs: Alternative system vs. system used in model center receiving 80 tons of feed ingredients per 8-hour shift

Item	Alternative		Model	
	Cost per year	Cost per ton	Cost per year	Cost per ton
	Dollars	Cents	Dollars	Cents
Labor:				
Production	4,221	20	3,710	18
Supervisory	1,014	5	1,014	5
Depreciation	4,481	22	3,943	19
Electricity	2,585	12	1,167	6
Interest	1,643	8	1,928	9
Forklift truck	338	2	338	2
Fuel (steam)	225	2	225	1
Maintenance	916	4	916	4
Total	15,423	74	13,241	64

types of systems generally feel that maintenance cost is relative, being about the same for either mechanical or pneumatic system. If a mill has a good maintenance policy, one system would not cost more than the other. Maintenance cost is a variable that is directly affected by the design of the system and the manufacturing techniques used.

Therefore, an estimate of annual maintenance for the pneumatic equipment is assumed to be the same as for that used in the model. This is an average figure that would tend to balance out over the life of the system.

Electricity cost for the pneumatic system is about twice that for the model (table 12). A total of 107 horsepower is required by the air system as compared with 73 1/3 horsepower by the mechanical. The pneumatic system would require about 10 percent more time each day than the mechanical system in the model for handling ingredients. This large electricity expense clearly illustrates one of the main disadvantages of using a pneumatic system for bulk unloading.

Depreciation for the pneumatic equipment is about 16 percent greater than for the mechanical. It is depreciated over 10 years, compared with 17 years for the mechanical.

Total cost of equipment for the large pneumatic system installed is about $96,130. This is about 5 percent less than the equipment cost of the mechanical (table 13). Both systems have the same hourly capacity.

A comparison of annual operating costs between the alternative system and that of the large model is similar to the same comparison in an analysis of the small model. Total annual operating costs for the pneumatic conveying system is about 8 percent more than that for the mechanical system (table 14). Greater cost per ton is mainly accounted for by the higher depreciation and electricity costs. Electricity cost per ton is double for the air system. The pneumatic system has a total of 255 horsepower as compared with 140 horsepower used in the model--a disadvantage of pneumatic conveying.

Table 13.--Equipment, capacity, and cost of alternative system for receiving bulk feed ingredients in model center receiving 200 tons per 8-hour shift

Equipment 1/	Quantity	Capacity	Approximate cost installed
	Number		Dollars
Truck scale, 10' x 50' w/dial printer	1	50 tons	8,540
Negative pressure blower assembly, 125 hp.	1	50 tons/hr.	12,600
Collector-airlock, 3 hp.	1	50 tons/hr.	7,140
Hopper car manifold	1		840
Unloading nozzles	2		700
Piping			2,800
Magnetic drum, 15" x 24", 1/3 hp.	1		2,660
Soft ingredient scalper, 1 hp.	1	40 tons/hr.	3,850
Grain cleaner, 10 hp.	1	2,000 bu./hr.	7,140
Automatic dump scale, surge bins (inlet and and outlet) with dial and printer	1	2,000 bu./hr.	8,260
Positive pressure blower assembly, 100 hp.	1	50 tons/hr.	9,800
Airlock and manifold, 3 hp.	1	50 tons/hr.	3,700
Piping			2,800
Switch station	1		420
Horizontal capstan car puller w/rope and hook, 7 1/2 hp.	1	5 55-ton cars	1,680
Forklift truck 2/	1	1 1/2 tons	4,800
Pumps, liquid, 3 hp. and 5 hp.	2	4,000 gal./hr.	2,800
Tanks, liquid	5	10,000 gal.	14,000
Boiler (steam) 3/	---	100 hp.	1,600
Total equipment cost			96,130

1/ Each item of equipment listed is complete with all accessories and parts necessary for installation.
2/ No installation charge.
3/ Prorated on basis of percentage of plant's steam used to heat liquids. The original cost of the boiler including installation is about $16,000.

The production and supervisory labor cost and interest cost of the model make up a larger proportion of the annual operating cost per ton than in an air system. However, if both systems are more automated, the initial cost of each increases rapidly. When highly automated, the pneumatic system's flow is regulated electrically, whereas the mechanical system uses regulatory feeders or some other type of mechanical means.

An analysis of this type must be straightforward. On such a basis, the evaluation of the pneumatic conveying system tends to suffer. However, as scheduling problems

Table 14.--Operating costs: Alternative system vs. system used in model center receiving 200 tons of feed ingredients per 8-hour shift

Item	Alternative		Model	
	Cost per year	Cost per ton	Cost per year	Cost per ton
	Dollars	Cents	Dollars	Cents
Labor:				
Production	5,863	11	7,521	14
Supervisory	2,028	4	2,028	4
Depreciation	8,040	15	6,540	13
Electricity	6,324	12	3,187	6
Interest	2,880	5	3,023	6
Forklift truck	780	2	780	2
Fuel (steam)	450	1	450	1
Maintenance	1,833	4	1,833	4
Total	28,198	54	25,362	50

in a mill increase, and as operations become more and more complex, pneumatic systems tend to be more competitive. More favorable initial cost, more favorable power requirement, and greater ease of housekeeping will move the pneumatic systems up in popular acceptance. Another important consideration is that insurance underwriters are lowering insurance premiums for pneumatic mills. This indicates that pneumatic systems have a greater safety factor.

Bagged Material

Many feed mills have reduced the quantity of incoming bagged ingredients. However, numerous mills in the survey still received over 50 percent of their incoming material in bagged form.

Various sizes of forklift truck are used to move bagged ingredients from rail car or truck into storage. A forklift truck is also used for warehousing finished feeds and moving materials in the feed plants.

Most feed mills handle 1-ton loads on wooden pallets. The pallets are handled in the warehouse by lift truck. This system of materials handling requires a large initial expenditure for pallets coupled with a high cost of pallet maintenance. Use of wooden pallets also has a high inherent cost in railroad and truck operations. This can be eliminated if another type of pallet is used.

Forklift equipment manufacturers are attempting to reduce warehousing costs with a number of forklift truck attachments. These attachments range upward in cost from $2,500 and can be installed on most late model lift trucks. Two of these attachments, costing about $3,500 each, use corrugated or solid fiber sheets in place of wooden pallets. The sheets range in price form 10 to 50 cents each. With one of these forklift truck attachments, a pallet load of feed may be pushed off or pulled onto the load plates. To take the loaded fiber pallet off the forklift blades, the pallet is positioned exactly where it will rest. The attachment has a pusher rack which holds the fiber pallet firmly in place while the forklift truck is reversed, leaving the load stationary in the storage area.

In loading the fiber pallet, the pusher rack is extended forward to the end of the load-carrying blades. At the base of this rack is a gripper jaw which grasps the fiber pallet firmly. The pusher rack is retracted as the machine moves forward. This moves the loaded pallet onto the load plate.

The second attachment is used to transfer a load of bagged material from a wooden pallet to a fiber pallet without manual handling. This transfer is made when material on wooden pallets is being shipped out in rail cars or trucks. The attachment has 2 sets of load plates. The space between these plates is contracted or expanded with a hydraulic system. To make the transfer, the wooden pallet of material is loaded onto 1 set of load plates. A fiber pallet is then inserted between the second set of load plates and the top of the material. The plates are contracted and the material is held tightly. The palleted material is then rotated 180° sidewise which places the paper pallet on the bottom. The plates are loosened, the wooden pallet removed, and the newly palletized material placed into rail car or truck. The second technique requires more manual labor than the first. However, there may be particular cases where this is preferred to use of fiber pallets entirely.

A third attachment is a bag-handling clamp, for use when pallets are not used for storage of materials. It is possible to use a forklift with this attachment to pick up a load of bagged materials which is not palletized.

The bag-handling clamp has 2 clamp arms and a load-guard attachment, which forms a complete unit. The arms are bolted to a hydraulically operated load grab which impacts the necessary lateral motion to the arms. To pick up a load, the lift truck with clamp arms open, pulls up to a stack of bagged materials; the clamp arms are brought together pressing the bags tightly at the sides, supporting the load.

This equipment moves unit loads consisting of 2 tiers of bags placed 1 in front of the other. No interlocking of bags is necessary unless the tiers are 8 bags in height. This is the suggested maximum unit load for safe efficient operation.

Floor space utilized by this system may be slightly less than with pallets. It is possible to stack 2 unit loads of 7 bags each. Storage stacks of 14 bags in height provide floor space utilization equal to the height of 3 pallets when that system is used. It is possible to stack 20 to 24 100-pound bags on a pallet. However, palletless stacks will probably range in height from 12 to 14 bags.

Assuming a feed manufacturer palletizes about 400 tons of bagged material--either raw material or combination of raw material and finished feeds--he would need about 500 wooden pallets costing $4.50 each. This is initial outlay of $2,250. With a bag-handling clamp costing about $1,800, installed, an initial savings of $450 could be realized from elimination of pallets.

To these savings must be added an annual saving in maintenance on wooden pallets. There are also savings in the labor which would be used in loading, unloading, and moving pallets from storage.

The new forklift systems are recent developments and are being used by some in the industry while being considered by others. They seem to have some advantages over the conventional wooden pallet system which has been used in the mixed feeds industry for handling bagged material for many years.

APPLICATION OF ANALYSES BY MANAGEMENT

Mixed-feed plants vary greatly in the volumes and types of feeds produced,

equipment used, utility rates, plant location, and plant management. It is impossible to set up standards and assumptions to suit all operations for all plants.

There are many decisions to be made concerning the operations and efficiency of a feed mill. Efficient materials handling is important throughout the entire manufacturing process. The receiving center is the beginning of materials handling in the mill and is also one of the more important centers.

The operating cost per ton is an extremely important factor in selecting a particular type of system, but it is not the only one. Four important considerations for management to keep in mind are: (1) Routing of materials, (2) nature of materials handled, (3) rate of conveying and (4) location of equipment. One type of system may be expensive and not particularly suited for one installation, however, in another installation it may be ideal. Systems should be "tailor made" for particular installations wherever possible.

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